CHM129

The Equilibrium Constant: Practice

1. Consider the following reaction:

$$2\ NO_{(g)} + 2\ H_{2(g)} \leftrightarrow N_{2(g)} + 2H_2O_{(g)}$$

A mixture at 300K initially contains 0.10mol of NO, 0.050mol of H_2, and 0.10mol of H_2O in a 1.0L vessel. At equilibrium, the concentration of NO is 0.062M. What are the equilibrium concentrations of H_2, N_2, and H_2O and the value of the equilibrium constant?

$$K = \frac{[N_2][H_2O]^2}{[NO]^2[H_2]^2}$$

	[NO]	[H_2]	[N_2]	[H_2O]
I	0.10	0.050	0	0.10
C	−0.038	−0.038	+0.019	+0.038
E	0.062	0.012	0.019	0.138

$$K = \frac{(0.019)(0.138)^2}{(0.062)^2(0.012)^2}$$

$K = 650$

[NO] = 0.062 M

[H_2] = 0.012 M

[N_2] = 0.019 M

[H_2O] = 0.14 M

2. Consider the dissolution of silver chloride, AgCl, in water:

$$AgCl_{(s)} \leftrightarrow Ag^+_{(aq)} + Cl^-_{(aq)} \quad K=1.8\times10^{-10}$$

Based on the value of K, would you consider AgCl a soluble or insoluble salt? Write the equilibrium expression and determine the [Ag^+] at equilibrium.

$K << 1$ Reactants are favored ∴ Insoluble salt

$K = [Ag^+][Cl^-] = 1.8\times10^{-10}$

$(x)(x) = 1.8\times10^{-10}$

$x = \sqrt{1.8\times10^{-10}}$

$x = \underline{1.3\times10^{-5} M} = [Ag^+]$

	[AgCl]	[Ag^+]	[Cl^-]
I		0	0
C		+x	+x
E		x	x

3. Consider the following reaction:

$$CO_{2(g)} + H_{2(g)} \leftrightarrow CO_{(g)} + H_2O_{(g)} \quad K=0.802 \text{ at } 395\ °C$$

If a reaction mixture contains initially 1.50mol of CO_2 and 1.50mol of H_2 are placed in a 0.750L container, what are the masses of CO_2, H_2, CO, and H_2O in the equilibrium mixture?

$$K = \frac{[CO][H_2O]}{[CO_2][H_2]} = 0.802$$

	$[CO_2]$	$[H_2]$	$[CO]$	$[H_2O]$
I	2.00	2.00	0	0
C	−x	−x	+x	+x
E	2.00−x	2.00−x	x	x

$$\frac{(x)(x)}{(2.00-x)(2.00-x)} = 0.802$$

$$\frac{x^2}{(2.00-x)^2} = 0.802$$

$$\frac{x}{2.00-x} = \sqrt{0.802}$$

$$x = \sqrt{0.802}\,(2.00-x)$$

$$x = (\sqrt{0.802})(2.00) - \sqrt{0.802}\,x$$

$$x = 0.945\ M$$

Initial concentrations:

$$[CO_2] = [H_2] = \frac{1.50\text{ mol}}{0.750\text{ L}} = 2.00\ M$$

Equil. concentrations:

$$[CO_2] = [H_2] = 2.00M - 0.945M = 1.06M$$

$$[CO] = [H_2O] = 0.945M$$

$$\text{mol } CO_2 = \text{mol } H_2 = (1.06M)(0.750L) = 0.795\text{ mol}$$

$$\text{mol } CO = \text{mol } H_2O = (0.945M)(0.750L) = 0.709\text{ mol}$$

$$\text{mass } CO_2 = 0.795\text{ mol}\left(\frac{44.01g}{1\text{ mol}}\right) = 35.0\text{ g } CO_2$$

$$\text{mass } H_2 = 0.795\text{ mol}\left(\frac{2.02g}{1\text{ mol}}\right) = 1.61\text{ g } H_2$$

$$\text{mass } CO = 0.709\text{ mol}\left(\frac{28.01g}{1\text{ mol}}\right) = 19.9\text{ g } CO$$

$$\text{mass } H_2O = 0.709\text{ mol}\left(\frac{18.02g}{1\text{ mol}}\right) = 12.8\text{ g } H_2O$$